

WHAT IS CLAIMED IS:

1. A gas concentration detecting apparatus applied to a gas concentration sensor including a sensor element sensing a concentration of a gas to be detected, the sensor element being equipped with a solid electrolyte member and one or more pairs of electrodes disposed on the solid electrolyte member, the apparatus comprising;
  - 5 a control unit configured to control a voltage applied to at least one of positive and negative terminals connected to the electrodes of the sensor element;
  - 10 a measurement unit configured to measure either an element current flow caused by the applied voltage corresponding to a concentration of a specific component of the gas, every time when the voltage is applied under the control of the applied voltage, or an electromotive force generated between the electrodes of the sensor element corresponding to the concentration of the specific component of the gas, every time when the voltage is applied under the control of the applied voltage;
  - 15 a change causing unit configured to cause a change in either the applied voltage to the sensor element or the element current through the sensor element;
  - 20 a change amount measuring unit configured to measure an amount of a change in each of a current value and a voltage value caused in response to the change caused in either the applied voltage or the element current;
  - 25 a calculation unit configured to calculate an amount of a resistance component to resist the element current flow through the sensor element on the basis of a ratio between the amounts of the changes in the current value and the voltage value; and
- a detection unit configured to detect abnormality relating to

controlling the sensor by utilizing information relating to calculating the amount of the resistance component calculated by the calculation unit.

2. The gas concentration detecting apparatus according to  
5 claim 1, wherein

the information relating to calculating the amount of the resistance component is at least one of the amounts of the changes in the current value and the voltage value and

the detection unit is provided with

10 a monitor unit configured to monitor the amount of the change in either the current value or the voltage value, the amount of the change being measured by the measurement unit; and

a determination unit configured to determine the abnormality on the basis of the amount of the change monitored by the monitor unit.

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3. The gas concentration detecting apparatus according to  
claim 2, wherein the determination unit is configured to determine that  
there occurs the abnormality, when the amount of the change in either  
the current value or the voltage value is equal to zero or a value  
20 substantially regarded as zero.

4. The gas concentration detecting apparatus according to  
claim 2, wherein

the control unit is provided with a feedback amplifying circuit  
25 connected to the positive terminal and the negative terminal of the  
sensor element, the voltage being applied to the sensor element via the  
feedback amplifying circuit,

the measurement unit is configured to measure either the  
current value or the voltage value in response to the change caused in

either the applied voltage or the element current at a position on an output side of the feedback amplifying circuit, and

the determination unit is configured to determine that there occurs the abnormality, when either the current value or the voltage value measured at the position on the output side of the feedback amplifying circuit is fixed at a boundary value or thereabouts of a range in which the feedback amplifying circuit operates.

5. The gas concentration detecting apparatus according to  
10 claim 4, wherein the feedback amplifying circuit is configured to have a function of limiting an output thereof into a predetermined range.

6. The gas concentration detecting apparatus according to  
claim 2, wherein

15 the change amount measuring unit includes an operated amount measuring unit configured to measure an actually operated amount of either the applied voltage or the sensor current when the change is caused in the either the applied voltage or the sensor current and

20 the determination unit is configured to determine the abnormality on the basis of the amount of the change in either the current value or the voltage value, which is monitored by the monitor unit, and the actually operated amount of either the sensor current or the applied voltage, which is measured by the operated amount  
25 measuring unit.

7. The gas concentration detecting apparatus according to  
claim 1, wherein the information relating to calculating the amount of the resistance component is the amount of the resistance component

itself and the detection unit is configured to detect the abnormality on the basis of the amount of the resistance component itself.

8. The gas concentration detecting apparatus according to  
5 claim 7, wherein

the control unit is provided with a feedback amplifying circuit connected to the positive terminal and the negative terminal of the sensor element, the voltage being applied to the sensor element via the feedback amplifying circuit,

10 the measurement unit is configured to measure either the current value or the voltage value in response to the change caused in either the applied voltage or the element current at a position on an output side of the feedback amplifying circuit,

15 wherein the feedback amplifying circuit is configured to have a function of limiting an output thereof into a predetermined range.

9. The gas concentration detecting apparatus according to  
claim 7, wherein

20 the change amount measuring unit includes an operated amount measuring unit configured to measure an actually operated amount of either the applied voltage or the sensor current when the change is caused in the either the applied voltage or the sensor current and

the detection unit includes

25 a determination unit configured to determine whether or not the actually operated amount is abnormal; and

a processing unit configured to change the actually operated amount to a predetermined value, to calculate an amount of the resistance component by using the predetermined value of the actually

operate amount, and to detect abnormality relating to controlling the sensor based on the amount of the resistance component resulting from the predetermined value of the actually operate amount.

5        10. The gas concentration detecting apparatus according to claim 9, wherein

the determination unit includes a unit configured to determine that the actually operated amount is abnormal, provided that the actually operated amount is lower than a predetermined threshold; and

10        the processing unit includes a unit configured to change the actually operated amount to the predetermined value in cases where the determination unit determines that the actually operated amount is abnormal.

15        11. The gas concentration detecting apparatus according to claim 10, comprising a unit configured to determine that there occurs abnormality relating to short circuit in the terminals of the sensor element when the abnormality relating to controlling the sensor is detected and when the actually operated amount is abnormal.

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12. The gas concentration detecting apparatus according to claim 9, wherein

25        the control unit is provided with a feedback amplifying circuit connected to the positive terminal and the negative terminal of the sensor element, the voltage being applied to the sensor element via the feedback amplifying circuit,

the measurement unit is configured to measure either the current value or the voltage value in response to the change caused in either the applied voltage or the element current at a position on an

output side of the feedback amplifying circuit,

wherein the feedback amplifying circuit is configured to have a function of limiting an output thereof into a predetermined range.

5           13. The gas concentration detecting apparatus according to claim 1, wherein

the change amount measuring unit includes an operated amount measuring unit configured to measure an actually operated amount of either the applied voltage or the sensor current obtained  
10 when the change is caused in the either the applied voltage or the sensor current, the actually operated amount serving as the information relating to calculating the amount of the resistance component and serving as the amount of the change in one of the current value and the voltage value and

15           the detection unit is configured to detect the abnormality with reference to the actually operated amount.

14. The gas concentration detecting apparatus according to claim 13, wherein the detection unit includes a determination unit configured to determine that there occurs the abnormality when the actually operated amount is zero or a value substantially regarded as being zero.

25           15. The gas concentration detecting apparatus according to claim 13, wherein

the control unit is provided with a feedback amplifying circuit connected to the positive terminal and the negative terminal of the sensor element, the voltage being applied to the sensor element via the feedback amplifying circuit,

the measurement unit is configured to measure either the current value or the voltage value in response to the change caused in either the applied voltage or the element current at a position on an output side of the feedback amplifying circuit, and

5 the determination unit is configured to determine that there occurs the abnormality, when either the current value or the voltage value measured at the position on the output side of the feedback amplifying circuit is fixed at a boundary value or thereabouts of a range in which the feedback amplifying circuit operates.

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16. The gas concentration detecting apparatus according to claim 1, wherein the resistance component to resist the element current flow through the sensor element is one of an impedance and an admittance of the sensor element.

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17. A gas concentration detecting apparatus applied to a gas concentration sensor including a sensor element sensing a concentration of a gas to be detected, the sensor element being equipped with a solid electrolyte member and one or more pairs of electrodes disposed on the solid electrolyte member, the apparatus comprising;

20 a control unit configured to control a voltage applied to at least one of positive and negative terminals connected to the electrodes of the sensor element;

25 a measurement unit configured to measure either an element current flow caused by the applied voltage corresponding to a concentration of a specific component of the gas, every time when the voltage is applied under the control of the applied voltage, or an electromotive force generated between the electrodes of the sensor element corresponding to the concentration of the specific component of

the gas, every time when the voltage is applied under the control of the applied voltage;

5        a change causing unit configured to cause a change in either the applied voltage to the sensor element or the element current through the sensor element;

      a change amount acquiring unit configured to acquire an amount of a change in at least one of a current value and a voltage value caused in response to the change caused in either the applied voltage or the element current; and

10      a detection unit configured to detect abnormality relating to controlling the sensor by utilizing information relating to the amount of the change acquired by the change amount acquiring unit.

18. The gas concentration detecting apparatus according to  
15 claim 17, wherein the change amount acquiring unit is composed of a change amount measuring unit configured to measure the amount of the change in at least one of the current value and the a voltage value caused in response to the change caused in either the applied voltage or the element current.